IN THE SPECIFICATION:

Paragraph beginning at line 9 of page 1 has been amended as follows:

The invention of the transistor evolved from studies ~~on~~ of the electrical characteristics of a semiconductor surface, particularly the surface electron state. However, with ~~regards~~ respect to electrical conduction due to the state of surface electrons themselves, many points have been left unanalyzed until today. This "surface state conduction" is extremely difficult to measure because electricity runs only in one or two electron layers of a crystal surface. However, thanks to the development of new measuring and inspecting techniques, such as a four-tip probe scanning tunnel microscope operating in an ultra-high vacuum and a microscopic four-tip probe, direct measurement of the surface state conduction has become possible and very interesting conduction characteristics have ~~begun to~~ become revealed as a result. To this end, it has ~~evolved~~ been determined that the electron state of a semiconductor surface has a unique characteristic totally different from that of the bulk state. In the electron device field, apparatuses of this type will play an important role in research and development of electron devices.

Paragraph beginning at line 4 of page 2 has been amended as follows:

In an evaluating apparatus using a scanning tunnel microscope according to the four-tip probe method, four probe tips are arranged linearly at regular distances, a current is caused to flow into a sample from the outer two of the probe tips, and a voltage drop caused due to the electrical resistance of the sample is measured by the inner two of the probe tips. At ~~that~~ <u>such</u> time, because there is only a very slight current flowing in these probe tips, only a voltage drop V on the sample can be measured without ~~receiving any~~ influence of the contact resistance at a point of contact of the probe tips with the sample. An electrical resistance according to the four-tip probe method is obtained by R = V/I where I is a measured current. As shown in ~~FIG. 10,~~ <u>FIGS. 10A and 10B</u> there is a correlation between the inter-probe-tip distance and the depth of probing into a sample. In order to obtain information of the ultra-surface of the sample, it is essential to arrange the probes at a the corresponding narrow distances ~~as~~ shown in FIG. 10B. In the related art, however, there is a limit in processing. This is to say that the diameter of the individual probe tip <u>has</u> served as a restriction so that a probe having a probe-tip pitch of several μm could not be manufactured.

Paragraph beginning at line 23 of page 2 has been amended as follows:

Conventionally, four-tip probes whose inter-tip distance is in the order of millimeters to centimeters have been used, and many studies on this type of probe were carried out. However, these conventional probes cannot be applied to surface analysis of semiconductor devices. Recently, an undergraduate research group of Tokyo University released a report (Applied Physics, 70th Volume, 10th Issue, 2001) on measurement of electrical resistance of a silicon crystal surfaces using a microscopic four-tip probe of a several μm pitch manufactured utilizing silicon micro-processing technology, such as ordinary lithography. For analyzing the outermost <u>or uppermost</u> device-surface, however, this several μm inter-tip distance is inadequate to achieve proper performance. An inter-tip distance of at most 1 μm or less is needed for doing so. Even if the above-mentioned silicon micro-processing technology is employed, it is difficult to manufacture a four-tip probe having an inter-tip distance of a such a sub-micron order.

Paragraph beginning at line 14 of page 3 has been amended as follows:

In a further related art study, positioning of measuring points on an object surface is carried out using an optical microscope. However, because a required measuring region for analyzing the outermost or uppermost device-surface is extremely small, it is difficult to achieve positioning using ~~on~~ the conventional optical microscope and, as an alternative means, a new observation technique, such as a scanning electron microscope (SEM) and an atomic force microscope (AFM) has been required. When an SEM is used, a sample is always irradiated with electrons during observation. This may ~~cause~~ produce noise and render accurate measurement of electricity impossible. On the other hand, in the case of an AFM, observation can be realized either in an ordinary atmospheric environment or a special atmospheric environment. However, when a multi-tip probe itself is used also as an image-obtaining probe, this may be a hindrance to accurate measurement for reasons such as (1) it is difficult to perform image analysis from signals detected by a plurality of probe tips arranged in a row and (2) the image is contaminated or otherwise damaged by scanning. Further, in the conventional AFM, it is a common practice to employ the light leverage method in which a mirror is mounted on a cantilever to detect

displacement. In this case, a sample is irradiated with laser light. Because laser light serves as an excitation energy source to cause surface atoms to enter an excited state, this has a considerable effect on the movement of electrons on a device surface and therefore also impedes accurate measurement of electricity. Alternatively, waves serving as excitation light can be removed by wavelength cutoff using a filter. However, this alternative cannot realize observation in a perfect dark field and would often encounter problems, such as decreases in sensitivity due to attenuation of light intensity.

Paragraph beginning at line 19 of page 4 has been amended as follows:

It is accordingly an object of the present invention to provide a ~~establish such~~ a processing method ~~as~~ to form a microscopic multi-tip probe whose inter-tip distance is on a sub-micron order, and to thereby provide such a microscopic multi-tip probe. Another object of the present invention is to provide an ultra-surface analyzing apparatus for analyzing the ultra-surface of a semiconductor device, the apparatus ~~of which has~~ having a function of positioning that does not influence electricity measurement in an extremely small region using the microscopic multi-tip probe.

Paragraph beginning at line 18 of page 6 has been amended as follows:

A multi-tip probe of the present invention comprises a cantilever formed using lithographic techniques, a plurality of lead portions formed on the cantilever, and a plurality of electrodes connected to each of the lead portions so that <u>the</u> pitch between the electrodes is narrower than pitch between the lead portions.

Paragraph beginning at line 20 of page 8 has been amended as follows:

In a scanning tunnel microscope according to the four-tip probe method to be used for semiconductor process evaluation, there is <u>the</u> ~~a~~ correlation ~~of~~ <u>shown in</u> FIGS. 10A and 10B between the inter-tip distance and the depth of probing into a sample, as described above. Moreover, in order to obtain information of an ultra surface, it is essential to arrange the probe tips at the corresponding narrow distance as shown in FIG. 10B of the figure. In the related art, there is a limit in processing, and as the diameter of the individual probe tip is restricted, an 8 μm pitch electrode is reported. However, a probe having an inter-tip distance ~~in~~ <u>on</u> the order of sub-microns cannot be manufactured. Consequently, the

present invention is intended firstly to fabricate a cantilever by the related method and then to form a probe having a microscopic inter-tip distance by processing a distal end portion of the cantilever utilizing nano-processing technology.

Paragraph beginning at line 11 of page 9 has been amended as follows:

For example, according to one technique, a single micro cantilever is fabricated by coating a substrate of silicon with a conductive thin film or by implanting ions into a substrate to make the substrate conductive. The resulting micro cantilever has a multi-tip conductive portion whose tips are spaced one from another and a shunt area formed on a distal end portion of the cantilever into which area the tips of the conductive portion merge. In order to obtain a less than 1 μm tip pitch, comb-shaped electrodes that are separated from each other are formed in the shunt area of the distal end portion of the cantilever by an etching process, such as sputter etching or gas assist etching using, for example, a focused ion beam (FIB) apparatus. The comb-shaped electrodes are used as a multi-tip probe. According to another technique, a single cantilever having a multi-tip conductive portion whose tips are spaced one from another and a non-

conductive area formed at a distal end portion of the cantilever is fabricated using photolithographic processes. Further, the ~~above-mention~~ above-described structure is obtained by depositing metal or carbon on the distal end portion of the cantilever, which is wired by a patch process, at desired distances by chemical vapor deposition (CVD) using an FIB apparatus. The microscopic multi-tip conductive portions may be formed by making the silicon, ~~silicone,~~ i.e. the cantilever, conductive using ion implantation techniques through irradiation with a beam rather than by CVD. It is possible to make processing time shorter by making lead portions that are not required in the microscopic processing as conductors for use with the multi-tip probe etc. in advance.

Paragraph beginning at line 12 of page 10 has been amended as follows:

In another alternative, a needle-shaped electrode may be manufactured ~~by~~ which is comprised of not only the comb-shaped electrode, but also by laminating or depositing a conductive substance (such as carbon or tungsten) on the distal end portion of the electrode. This electrode can make contact with a sample in an improved manner. In the manufacture of the electrode by processing the deposited metal

using an FIB apparatus, an ultra-microscopic multi-tip probe whose inter-tip distance is several hundreds to several nm can be formed with ease, depending on the metal film thickness. In the foregoing description, an FIB is used as a source of a charged particle beam. Alternatively, however, the processing, which is gas assist etching or CVD, may be realized using an apparatus using an electron beam.

Paragraph beginning at line 24 of page 10 has been amended as follows:

Further, for analyzing the outermost or uppermost surface of a device, it is essential to specify the position of the device surface.

Paragraph beginning at line 10 of page 12 has been amended as follows:

One embodiment will now be described in which a four-tip probe is manufactured by a technique according to the present invention. Using a silicon substrate as a starting material, an elongated cantilever 1 of a 16 μm width, which is shown in FIG. 1, and its base portion 2 are fabricated by lithography. Four lead paths 3 serving as prospective probe tips are patterned in platinum film at distances of 35 μm apart in the base portion 2 and at distances of 3.4 μm apart

in the cantilever 1. The material of the lead paths 3 may alternatively be <u>a different</u> metal, such as aluminum or tungsten. The distal end portion of the resultant cantilever 1 is shown in enlarged scale in FIG. 2A. As is understood from FIG. 2a, the distal end portion of the cantilever 1 is tapered and, the individual lead paths 3 formed thereon by patterning extend to and terminate in a shunt area 4 serving as a common conductive portion. Using an FIB apparatus, the resulting distal end portion is microscopically processed to achieve the shaping and processing of four probe tips spaced at sub-micron distances. This sputter etching may include removing only the platinum film or may include removing the platinum film together with silicon substrate portions in a comb-shaped pattern to facilitate contact with a sample surface.

Paragraph beginning at line 7 of page 15 has been amended as follows:

Another embodiment will now be described in which a four-tip probe is manufactured by another deposition technique of the present invention using an FIB apparatus. Using a silicon substrate as a starting material, an elongated cantilever 1 of a 16 μm width, which is shown in FIG. 3, and its base portion 2 are fabricated by lithography. Four lead

paths 3, serving as prospective probe tips, are patterned at ~~distances~~ a spacing of 35 μm in the base portion 2 and at ~~distances~~ a spacing of 3.4 μm at the cantilever 1. The distal end portion of the resultant cantilever 1 is shown in enlarged scale in FIG. 4A. As is understood from FIG. 4A, the distal end portion of the cantilever 1 is tapered and the individual lead paths 3 formed by patterning extend to and terminate in the distal end portion. The present embodiment is similar to the previous embodiment except that no conductive shunt area is formed. Using an FIB apparatus, the resulting distal end portion is microscopically processed to achieve the shaping and processing of four probe tips spaced at sub-micron distances.

Paragraph beginning at line 21 of page 16 has been amended as follows:

Another embodiment, unlike the previously mentioned embodiment using only a comb-shaped electrode, will now be described in which, in order to improve the ease of contact with a sample, a needle-shaped electrode is formed by laminating and depositing a conductive substance (such as carbon or tungsten) on the distal end portion of each electrode by the CVD process using an FIB apparatus. FIG. 5 shows the processing procedures of the present embodiment,

where FIG. 5A shows a state before the processing, and FIG. 5B, 5C and 5D respectively ~~shows~~ show the states after FIB processes 1, 2 and 3. As shown ~~in FIG. 5,~~ the processing procedures of the present embodiment are substantially similar to those of the previously mentioned embodiment with the exception of FIB process 3. Namely, what is shown in FIG. 5A is an elongated cantilever 1 fabricated by lithography and having four-needle lead paths 3 patterned in platinum film. In FIB process 1, the distal end portion of the cantilever 1 is scaled by sputter etching using an FIB apparatus, thereby forming a rectangular projection 5. Notably, this process is not absolutely essential and may be omitted. Namely, the processing procedure may advance to the CVD process as with Embodiment 2, skipping FIB process 1. In FIB process 2, lead paths 31 connecting each microscopic electrode 6 and the respective lead path 3 are microscopically formed on the distal end portion by the CVD process using an FIB apparatus, thereby shaping microscopic electrodes 6 spaced one from another by a sub-micron distance. Then, in FIB process 3, a vertically directed needle 61 is formed on each microscopic electrode 6 of the distal end portion further by the CVD process using an FIB apparatus. Because the thus formed needle 61 contacts a sample surface, the present embodiment can improve the ease of contact with a sample surface as

compared to Embodiment 2 using only the comb-shaped electrode. The forming of the vertically directed needle 61 on each microscopic electrode 6 by the CVD process using an FIB apparatus an be applied to the forming of microscopic probe tips 6 in a spaced manner by etching a shunt area 4.

Paragraph beginning at line 18 of page 18 has been amended as follows:

A still further embodiment will now be described in which, when an elongated cantilever 1 is fabricated by lithography, a convex bank 11 is formed on the distal end portion of the cantilever 1 and four-probe-tip lead paths 3 are patterned in platinum film on the resulting cantilever 1, thereby causing uniform contact pressure to be exerted on every probe tip. ~~FIG. 7 shows~~ Figs. 7A-7G show this processing procedure. What is shown prior to processing is the cantilever 1 fabricated by lithography. A cross-sectional view taken along A-A' that is a plan view of FIG. 7A is shown in FIG. 7D and 7E, the bank 11 being the distal end portion of the cantilever 1 is partially scaled by sputter etching using an FIB apparatus, thereby forming a rectangular projection 5. As is noted from FIG. 7E, ~~7E,~~ in the resulting cantilever 11, a saddle-back-shaped convex bank 11 is left un-scaled on the rectangular projection 5. In FIB process 2 shown in FIG. 7F

and FIG. 7G, lead paths 31 connecting each microscopic electrode 6 and the respective lead path 3 are microscopically formed on the distal end portion by the CVD process using an FIB apparatus, thereby forming four probe tips spaced one after another by a sub-micron distance. As is apparent from FIG. 7G, the microscopic electrodes 6 are deposited on the surface of the saddle-back-shaped convex bank 11 and hence have a saddle-back shape. Therefore, when the resulting cantilever 1 is brought close to a sample surface, the crest of the saddle-back comes into contact with the sample surface. In the case of the present embodiment, if the crest of the bank 11 at the distal end portion of the cantilever 1 is uniformly formed as the original cantilever 1 is fabricated by lithography, the convex portion of the microscopic electrodes 6 also are uniform in height, thereby causing a stabilized contact relation between the sample surface and the plural microscopic electrodes 6. Alternatively, the bank 11 at the distal end portion of the cantilever 1 may be formed by reactive dry etching or wet etching. Further, the forming of such a bank 11 on the distal end portion of the cantilever 1 can be applied to the forming of the cantilever having on its distal end portion a shunt area 4.

Paragraph beginning at line 11 of page 23 has been amended as follows:

The micro cantilever manufacturing method according ot one aspect of the present invention comprises the steps of ~~of:~~ fabricating a cantilever having a plurality of lead portions spaced one from another and a shunt area formed at a distal end portion of the cantilever ~~cantilever;~~ by a micro cantilever fabrication technique utilizing lithography, ~~;~~ and forming a probe on the cantilever by processing the shunt area of the distal end portion of the cantilever by sputtering or gas assist etching using a beam of focusing charged particles. According to another aspect of the present invention, the method comprises the ~~steps;~~ steps of fabricating ~~fabrication~~ a cantilever having a plurality of lead portions spaced one from another, by a micro cantilever fabrication technique utilizing lithography, ~~lithography;~~ and forming a probe on the cantilever by CVD which irradiates a beam of ~~focusing~~ focused charged particles to the distal end portion of the cantilever while spraying a gas of raw material thereto. Therefore, it is possible to easily obtain electrical information of microscopic portions and ultra-surface, which was impossible in the conventional art. In the method of manufacturing a microscopic multi-probe according to the present invention, because the probe tips are formed into a resilient structure

by CVD, some variation in height of the probe tips are allowed, thereby increasing the easiness of the probe tip fabrication drastically.

Paragraph beginning at line 9 of page 24 has been amended as follows:

The surface characteristic analyzing apparatus according one aspect of ~~to~~ the present invention comprises~~:~~ first a micro cantilever having on its distal end portion a microscopic multi-tip probe~~;~~, an AFM-dedicated micro cantilever having on its distal end portion a dedicated microscopic multi-tip probe; the AFM-dedicated micro cantilever being spaced by a known, predetermined distance from the first micro-cantilever, and ~~first-named micro-cantilever;~~ means for driving the two micro cantilevers independently of each other into contact/non-contact states with respect to a sample. Therefore, the apparatus has the functions of~~:~~ obtaining an observed imaged of a sample surface by an AFM with the microscopic multi-tip probe in a non-contact state~~;~~, determining a measuring region from the observed image~~;~~, positioning the microscopic multi-tip probe in the determined measuring region and bringing the microscopic multi-tip probe into contact with the determined measuring region. Even in electricity measurement at an

arbitrary position (e.g., a wiring portion) where positioning was difficult to take place on a conventional optical microscope, accurate measurement of electricity can be achieved by an array probe that can be combined with AFM. Further, the means for driving the cantilevers between a contact state and a non-contact state can be achieved with ease by employing a temperature-controlled bimetal-type actuator, a comb-shaped electrostatic actuator, or a piezoelectric micro-actuator. Furthermore, by using the self-detection method in which a strain gauge is mounted on the cantilever, electricity measurement in perfect dark field can be realized.